Subject:
Date

session 3

Alvolar ventilation : the act of gas exchange

ventilation ↓ | Perfusion
supply the blood with Fresh gas | pumping the blood to the lungs

Tidal volume (TV): the v. of air entering/leaving into mouth & noose in & out per min
(normal 70 kg individual 500ml/breath) (in normal unforced breathing)

Residual Volume (RV) : the volume of air that is left in lungs after a maximal forced expiration (1,5 lit)

Expiratory Reserved Volume (ERV): the Volume that is expelled from the lungs during a maximal forced expiration that begins at the end of normal tidal expiration (1,5 lit)

بازدم

Inspriatory Reversed Volume (IRV): The Volume of air that is inhaled into the lungs during a maxmial inspiratory effort beging at the end of normal tidal inspiration (2.5 lit)

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Functional Residual Capacity (FRC):

Volume of air inside the lungs at the end of normal tidal expiration.

$$FRC = ERV + RV$$

Vital Capacity (VC): The volume of air expelled during a maximal expiratory effort ~~[illegible]~~ after a maximum forced inspiration:

$$VC = IRV + TV + ERV$$

Inspiratory Capacity (IC):

IRV def — (~~inspiration~~) expiration.

$$IC = IRV + TV$$

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Date

Negative Pressure breathing:

contraction of inspiratory muscles
(1) diaphragm (dome shaped/250 cm² separates thoratic & abdominal Cavition)
(2) external intercostal muscle

eupnea (normal (unForced breathing) —supire position

Transmural Pressure Gradiant

Intra pleural pressure (intra thoratic pressure)

because of mechanical interaction between lungs & chest walls

Inspiratory muscles
- (1) diaphragm
- (2) external inter costal muscles
- (3) accessory muscles
  - sternocleidomastoid muscle

active expiration
- exercise
- Siging & speech
- Expiratory phase of sneezing and caughing
- emphysema

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active Expiratory muscle:

rectos abdominis

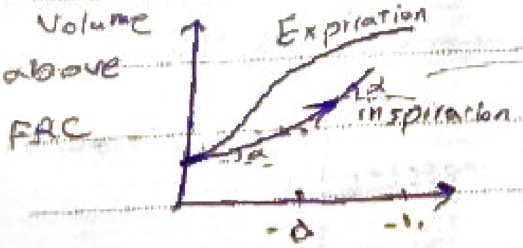
transverse abdominis

internal / external oblique

internal intercostal muscle

Compliance: it shows distansibility

$C = \frac{dV}{dP}$ $[C] = \frac{m^3}{pa}$



→ slope of the tangent Line

Interpleural pressure cm-water

Stiffness $\propto \frac{1}{\text{compliance}}$

a spring stiffness = $\frac{۱۰۰\ N}{1\ mm}$ = ۱۰۰ $\frac{N}{mm}$

strech
S.l mm
F = ۱۰۰ N

compliance = $\frac{1}{۱۰۰}$ $\frac{mm}{N}$

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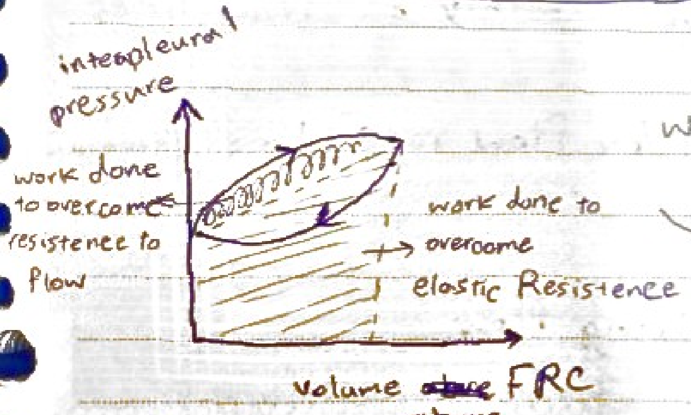
Elastance: medical term to describe the stiffness of hollow organs inside the body.

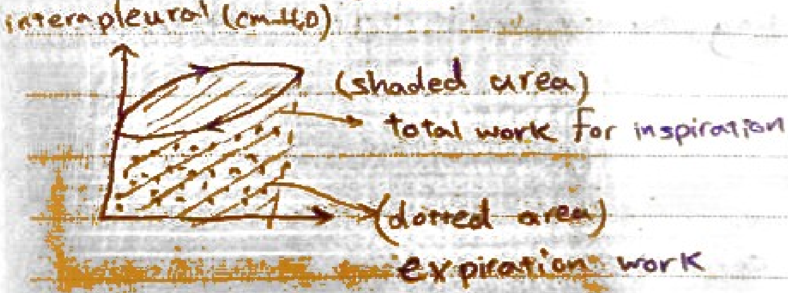
breathing work: depth & rate → manage to minimize breathing work.

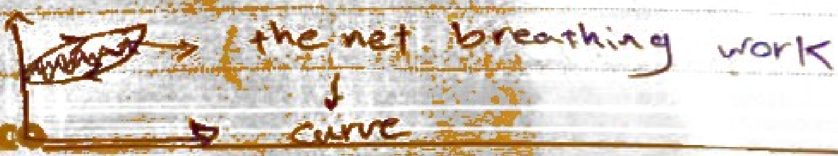
work done to overcome the elastic Resistence of chest wall & diaphragm	+	work done to overcome the resistance of flow



$$W = \int_0^b p\, dv$$

area beneath the curve





Subject:
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Flow Resistance

① the rate at which the air flows.

② Conducting airway diameter

③ flow regim

flow Regim → Lamina Flow
flow Regim → turbulent Flow

مسیر جریان

Lamina: fluid particles move smoothly on stream lines

(small conducting airways with low flow rate - like terminal bronchioles)

Turbulent Flow: random mixing flow

occurs in big conducting airway with high flow rate

like trichea.
نای

for intermidiate-sited conducting airways → transitional

flow (between laminar & turbulent flow)

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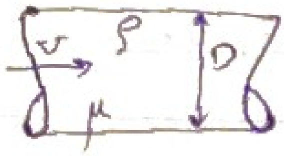


ρ : density $\left(\frac{kg}{m^3}\right)$

D : diameter (m)

μ : viscosity $\left(\frac{N}{m^2}\cdot s\right)$

V : velocity $\left(\frac{m}{s}\right)$

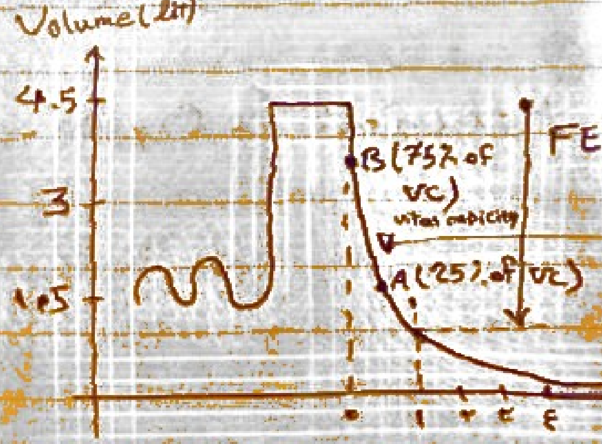
Reynold's number (Re) $= \dfrac{\rho V D}{\mu}$ (dimensionless number)

$$[Re] = \frac{\frac{kg}{m^3}\times\frac{m}{s}\times m}{\frac{\frac{kg.m}{s^2}}{m^2}\cdot s} = \frac{\frac{kg}{m.s}}{\frac{kg}{m.s}} = 1$$

Re shows → $\dfrac{\text{inertial forces}}{\text{Frictional forces}}$

Re↑ turbulent flow

Re↓ laminar Flow



FEV (Forced expiratory volume - 1 second)

slope: FEF 25-75% = forced expiratory flow rate (of vital capacity)

steep slope ⇒ normal

shallow slope ⇒ respiratory abstruction

Spirometry

FVC : vital capacity

expelled the air by maximal force

$\dfrac{FEV}{FVC}$ = flow Resistance ~ 80%

Subject: fraction ⇒
Date

diffusion : alveoli & pulmonary capillaris (مویرگ های ریوی)

blood gas barrier alveolar resistance

diffusion capacity = $\frac{\dot{V}_{gas}}{P_a - P_c}$ → The volume rate of gas ($\frac{mL}{min}$)

P_a: Partial preasure of gas inside alveoli

P_c: Partial preasure of gas inside pulmonary capillaris

[diffusion capacity] = $\frac{\frac{mL \text{ of gas}}{min}}{mmHg}$
(da)

Resistance of diffusion = $\frac{1}{\text{diffusion capacity}} = \frac{P_a - P_c}{\dot{V}_{gas}}$ → $\left[\frac{mmHg}{\frac{mL \text{ of gas}}{min}}\right]$

θ: chemical interaction between Hemoglobin & Oxygen

↳ Resistance

θ: shows $\frac{\frac{mL\ O_2}{min}}{\frac{mL\ blood}{mmHg \text{ Partial preasure of Oxygen}}}$

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V_c : Volume of blood inside pulmonary capillaris

$$[\theta V_c] = \frac{\frac{mL\ O_2}{min}}{mmHg\ \text{Partial preasure of } O_2}$$

$$\text{Resistance} = \frac{1}{\theta V_c}$$

$$\frac{1}{D_L} = \frac{1}{D_m} + \frac{1}{\theta V_c}$$

$\frac{1}{D_L}$ → total Resistance

$\frac{1}{D_m}$ → Resistance of blood-gas barrier

$\frac{1}{\theta V_c}$ → Resistance of chemical Reaction

diffusion of CO_2 → approximately 20 times faster than O_2.

Red blood cell (erythro cyte) → 0.75 - 1.2 s in pulmonary capillary. 0.25 s in excercise

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Subject:
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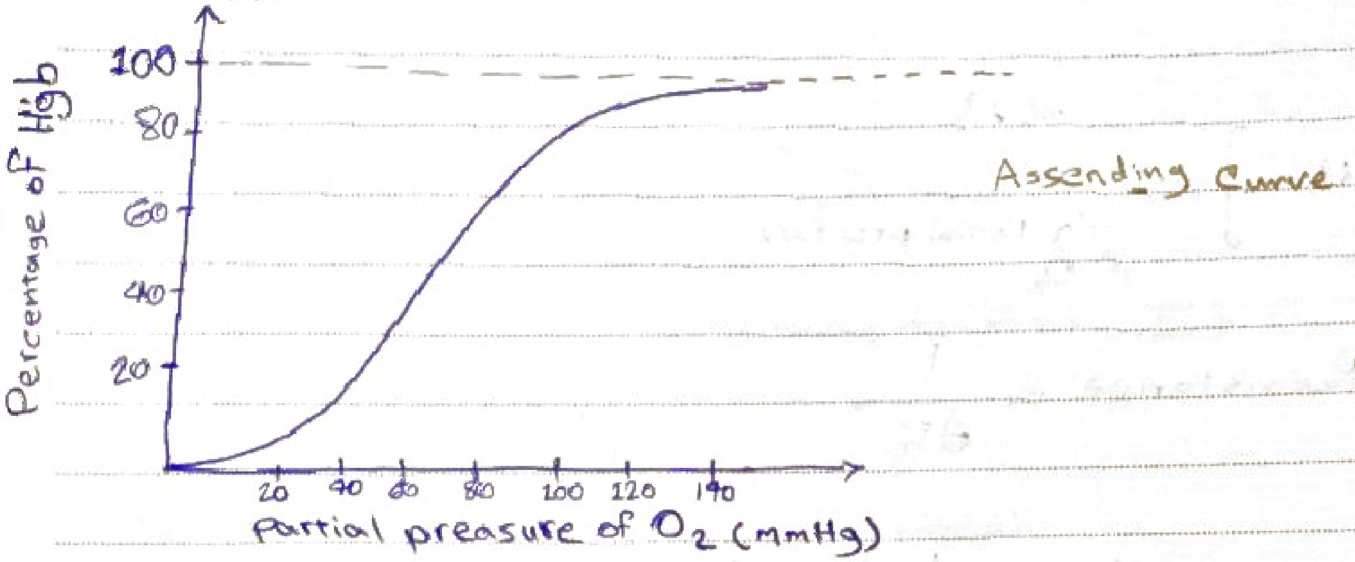
Oxygen dissociation Curve:



40 mmHg → 75% Hgb / 1 gr pure Hgb → 1,34 mL O_2

100 mmHg → 97.5% Hgb / 15 gr Hg → 100 mL blood.

maximum O_2 Carrying - Capacity = $15 \times 1{,}34 = 20{,}8 \frac{mL\ O_2}{100\ mL\ blood}$

O_2 can be dissolved in blood:

$0.003 \left[\frac{\frac{mL\ O_2}{100\ mL\ blood}}{mmHg\ \text{Partial preasure of } O_2} \right]$

$P_{O_2} = 100\ mmHg \rightarrow 0.3 \frac{mL\ O_2}{100\ mL\ blood}$

$\star\ CaO_2 = \left[SaO_2 \times \text{grams of HgL} \times 1.34 \frac{mL\ O_2}{gr\text{-}Hgb} \right] \times 0.003\ P_{O_2}$

CaO_2 = oxygen content of arterial blood

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S_{aO_2} = the percentage of saturation of Hgb

$$[C_{aO_2}] = \frac{mL\,O_2}{100\,mL\ blood}$$

Cardio Vascular System (سيستم قلبي عروقي)

heart + blood vessels

Main functions:

① supply oxygen for body tissues.

② supply nutrients

③ Remove Carbon dioxide & other waste materials

④ Temperature Regulation

Blood Circulation:

① systemic circulation

② pulmonary " — blood enriches with oxygen.

③ Cornary "

Subject:
Date

Components:

(① heart - (② artery) - (③ generation - bifurcation)
branches ↑ (above "bifurcation")
(سرخرگ) (under "artery")

④ arteriole (diameter < 500 μm)
(درشریانچه)

⑤ metarteriole (terminal arterioles)

⑥ Capillaries (diameter ~ 8 μm)

endothelial Cell (one layer) → interface between blood & vessel

tight junction

penetrate

Venules (وریدچه) - veins (ورید)

Vena Cava (Interior - superior)

حفره ↑ (above "chambered")

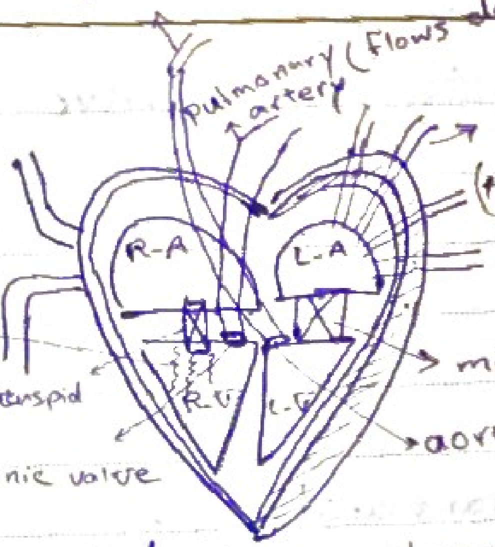
Heart → four chambered pump (2 pumps in series)

دهلیزها (above "atrial") دهلیز (above "atrium")

atrial → atrium

Subject:
Date

بطین‌ها
ventricles



→ the disease is called: Valve prolaps - Valve collapse

heart valves: tricuspid valve - mitral valve - - pulmonic valve - aortic valve

Valves {
- one-direction flow
- allow different locations to have different preasur without backward flow.

Atrio-Ventricular valve (AV-valves)

Semi-lunar valve (SL-valves) نیم هلالی

Subject:
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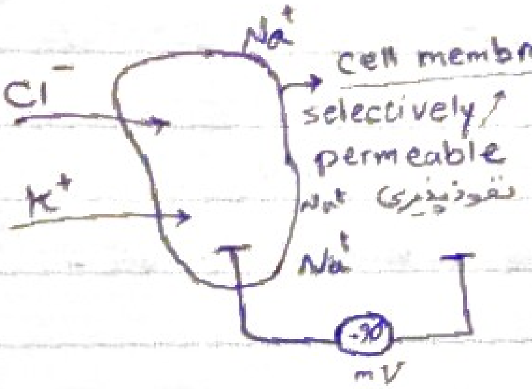
Cardiac muscle fiber, is called Myo Cardium

which is a elongated - multinucleated, striated muscle.
↓
15 x 15 x 150 Microns



دیواره
transmural electrical potential difference

Principal electrolyte ions :

Sodium - Pottasium - Chloride

anions associated with large molecules & proteins.

Permeability → Sodium ↓ is low
→ Pottasium & chloride ↑ is high

Counter blance

osmotic pressure

Na^+ → continually leaks into the cell

the mechanism is called: Active Sodium/Pottusium pump

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Excitability تحریک‌پذیری

↳ ability of a cell to respond to an external excitation.

excitation → permeability changes → Na^+ will enter → K^+ pumps out → Depolarization → Contraction → Repolarization

---

Automaticity : The ability of certain class of cells to be stimulated spontanessly (خودبخودی) without external stimulation.

Group of cells in posterior wall of right atrium. → High Automaticity → Sino-Atrial node (SA-node)

Pacemaking site of heart.

Atrio-Ventricular node (AV-node) → Lower inter atrial septum.

It provides Limiting effect cannot transfer impulses faster

Subject:
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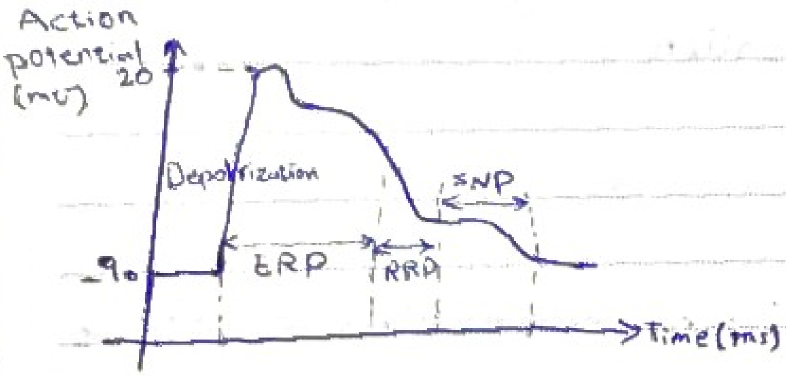
than 200 bpm.

Atrial tachycardium → atrio-ventricular block

Electro Cardiogram (ECG):



ERP = Effective Refractory Period. (250 ms)

RRP = Relative Refractory Period. (50 ms)

SNP = Super normality Period. (50 ms)

The electrical activity of heart is a useful piece of information. → measuring the electrical field in frontal plane

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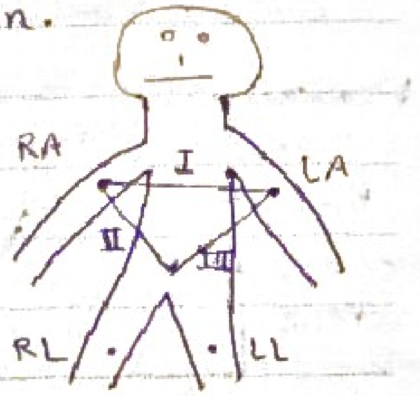
Dipole moment vector ($\vec{M}$) → Magnitude: electrical charge xd
→ direction:

d = sepration distance

Cardial Cycle ventricular depolarization.

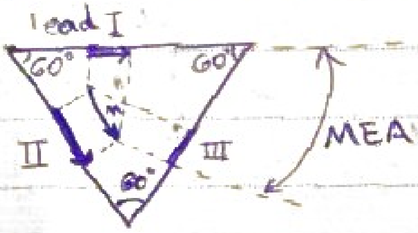


lead → Pair of electrods

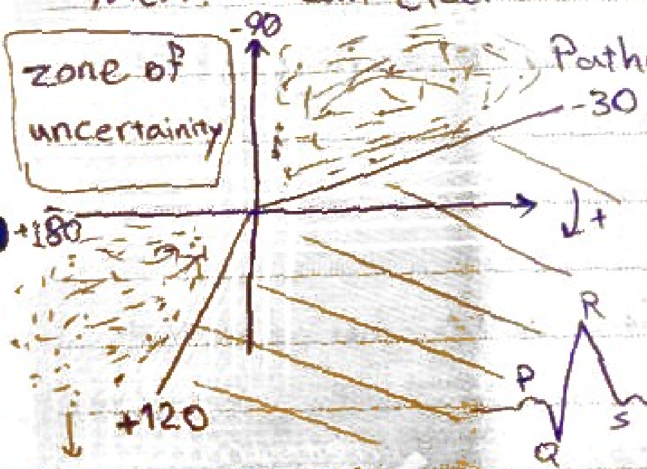
projection of $\vec{M}$ in lead I direction

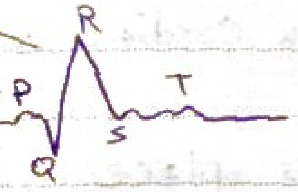
equilateral triangle

Einthoven's triangle



MEA: Mean Electrical axis (MEA) / OR (QRS axis)





P: atrial depolrization

QRS: Ventricular depolrization

T: " Re-polarization

- Sinus tachy cardia
- Sinus brachy Cardia
- Atrial tachy Cardia
- Ventricular tachy Cardia
- Ventricular fibrilation

} arithmia

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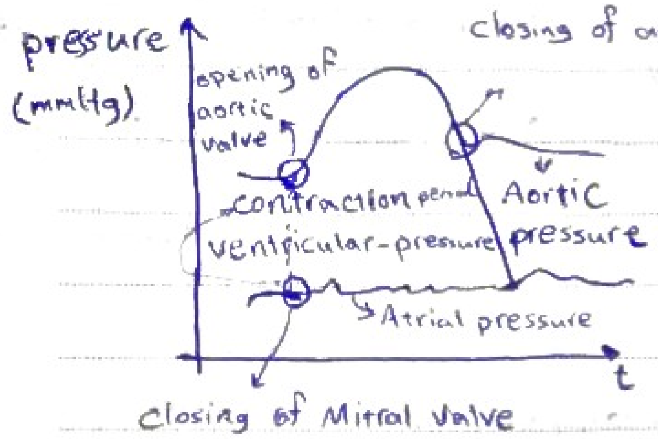

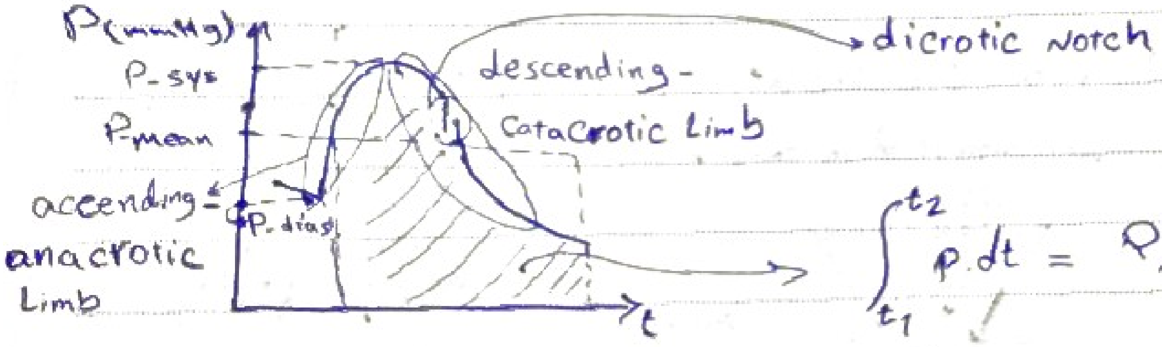

$$\int_{t_1}^{t_2} p \, dt = P_{mean} \times (t_2 - t_1)$$

Cardiac Cycle:

① Systole: Portion of a cardiac cycle during which blood ejection takes place.

② Diastole: Portion of a cardiac cycle during which chamber-refilling takes place.

Systolic pressure: Maximum pressure during systole.

Subject:
Date

تغییر فشار خون

Diastolic pressure: Minimum Pressur During Diastole.

Mean pressure (P_{mean}):

$$P_{mean} = \frac{\int_{t_1}^{t_2} p\,dt}{t_2 - t_1}$$

$\Delta t = t_2 - t_1$: duration of a cardiac cycle.

EDV: End diastolic volume (Maximum volume of blood inside left ventricle)

ESV: End Systolic Volume (Minimum volume of blood in LV)

SV = EDV - ESV

↓

Stroke-volume ($\simeq 70 \frac{ml\ blood}{beat}$): volume of blood has ejected from left ventricle in one beat.

Heart-Rate (HR) → number of heart beats in a minute

→ Cardiac Output (CO) = SV × HR

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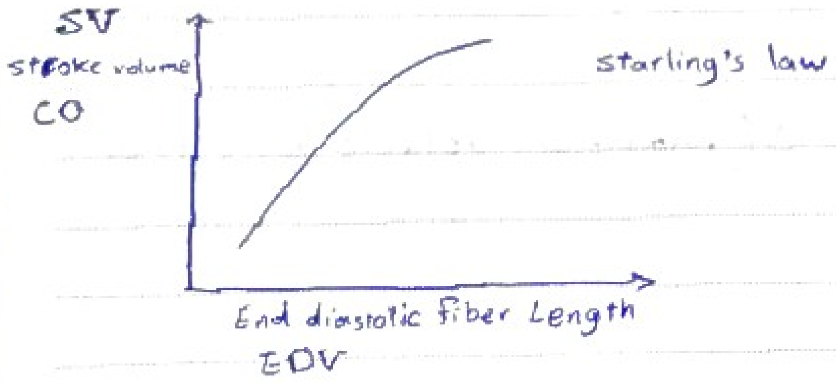
Stroke-work (SW) = $P_{mean} \times SV$

Ejection Fraction (EF) = $\frac{SV}{EDV} \times 100 \simeq 55\%$

افزایش برگشت جریان وریدی

starling's law = by increasing of venous return → higher stretch of myo cardial fibers → More ForceFull Contraction at the very next beat of the heart.



پیشوا

Preload : establishes the fiber length before contraction

Afterload : The force against which left ventricle must contract to eject the blood.

پسوا

Contractily : The ability of a myo cardial fiber to contract at a given length

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→ by activation of autonomus nervous system } → higher Contractility

→ release of a neurotransmitter (norepinephrine)

Cardiac Cycle

(HR : 70 beats/min)

time →

0 ۰٫۱ ۰٫۲ ۰٫۳ ۰٫۴ ۰٫۵ ۰٫۶ ۰٫۷ ۰٫۸

Atrium	sys.	diastole		
Ventricle	dias.	sys.	diastole	
AV-Valves	open	close	open	
Sl-Valves	close	open	close	
heart sounds	S4, S1		S2	S3

S1: lub sound of the heart (due to closing of AV-Valves)

S2: dub sound of the heart (due to closing of SL-valve)

S_3 & S_4 → loss distinct

low pitched - low intensity
Frequency 10-500 Hz
hearts sounds